WATER QUALITY AND USE

BENEFICIAL USE ATTAINMENT

The Missouri Department of Natural Resources and the Clean Water Commission are responsible for setting and enforcing the water quality standards for Missouri. These standards have specific acceptable ranges for several indicators of water quality including: pH range 6 to 9, fecal coliform levels not to exceed 1,000 colonies per milliliter, temperatures for coldwater fisheries should not exceed 68° F, and temperatures for coolwater fisheries should not exceed 84° F. Nitrate levels of 10 mg/l or less are the standard criteria for drinking water supply. Dissolved oxygen levels for cool and warmwater fisheries should not fall below 5 parts per million (ppm) and should not fall below 6 ppm for coldwater fisheries (MoCSR 1991).

The Missouri portion of the watershed has waters classified for all beneficial uses designated by the Missouri Department of Natural Resources, except industrial (Table WQ01) (MDNR 1996a). There is also one stream reach which is designated as an Outstanding State Resource Water; Ketchum Hollow, 1.5 miles of stream located within Roaring River State Park, Barry County. Streams given this designation have a high level of scientific or aesthetic value and remain relatively undisturbed. Under this designation an anti-degradation review must be conducted on any applicant wishing to construct or upgrade a facility that discharges to Ketchum Hollow (R. Laux, MDNR, pers. comm.).

In addition to stream use classifications, the watershed has three lakes which have been given beneficial use designations. These are: Table Rock Lake, Class 1, classified for livestock watering, aquatic life, whole body contact recreation, drinking water supply, and boating; Lake Taneycomo, Class 1, classified for livestock watering, aquatic life, coldwater fishery, whole body contact recreation, boating, and drinking water supply; Bull Shoals Lake, Class 2, classified for livestock watering, aquatic life, coldwater fishery, whole body contact recreation, and boating (MDNR 1996b).

Three watershed areas in the Missouri portion of the watershed have been designated as critical for the protection of drinking water supplies and are protected under state law 10 CSR 20-7.031. These include all waters upstream of Table Rock Dam in Missouri (1,150,300 acres), the watershed upstream of the intake for College of the Ozarks (17,139 acres) on Lake Taneycomo, and the watershed upstream of the intake for the City of Branson (3,241 acres) on Lake Taneycomo. Critical watershed requirements apply to Class IA CAFOs, which are operations that are permitted to house more than 7,000 animal units. These CAFOs must have an approved spill prevention plan (MDNR 1997) .

Several stream reaches in the Missouri portion of the watershed have been designated as coldwater fisheries by MDNR, including: Terrell Creek in Christian County from Double Spring to the mouth, Lake Taneycomo in Taney County for its entire stretch, Barren Fork from Smith Spring to the mouth, Roaring River from Roaring River Spring to Table Rock Lake, and Bee Creek in Taney County upstream of the MO Hwy. 65 bridge (MDNR 1986a).

MDC has identified several streams in the watershed as important coldwater resources in addition to those listed above. These include: Lake Taneycomo, Roaring River, and Bee Creek, all listed above and having MDNR classification as coldwater fisheries, and Hobbs Hollow, Dogwood Creek, Indian Creek, Turkey Creek a tributary to Lake Taneycomo in Taney County, Turkey Creek a tributary to Little North Fork White River in Ozark County, Roark Creek, Woods Fork Bull Creek, and the lower section of Bull Creek (Figure WQ01).

Most beneficial use attainments should be met with the exceptions of Table Rock Lake occasionally having levels of fecal coliform bacteria that exceed standards at some public swimming beaches (MDNR 1986a). Localized, excessive eutrophication and the resulting increases in phytoplankton and lower water clarity in Table Rock Lake have been a cause for concern. Water clarity directly above Table Rock Dam decreased an average of 0.82 meters in the period from 1974 to 1994 (USGS 1995). Three probable sources of excessive nutrification have been identified in the Table Rock Lake watershed. These include the James River with municipal sewage discharges from Nixa, Ozark, and Springfield WWTFs, residential septic systems associated with increasing populations, and livestock and poultry wastes from northwest Arkansas and the western portion of the watershed.

Lake Taneycomo, usually during late summer and fall, has dissolved oxygen levels that fall below dissolved oxygen standards for coldwater fisheries due to releases of hypolimnetic water from Table Rock Dam (MDNR 1986a)

Whole body contact limits for fecal coliform bacteria have been exceeded four times in Roaring River Spring and one time in Roaring River at the state park during the early 1990s. Dry Hollow has also experienced fecal coliform levels above state standards for losing streams in the early 1990s on two occasions (Hemsath 1992).

Section 303(d) of the Federal Clean Water Act requires states to list waters not expected to meet established state water quality standards even after application of conventional technology-based controls for which Total Maximum Daily Load (TMDL) studies have not yet been completed. The 1996 list of waters needing a TMDL study included Lake Taneycomo. In 1996 a TMDL study for Lake Taneycomo was listed as low priority, and it has not yet been targeted for a study. Lake Taneycomo is on the 1998 proposed list to remain designated for a study, and the priority has been updated to medium. An additional list of waters proposed for the State of Missouri 303(d) list has been submitted by the Sierra Club and Missouri Stream Team 714 including the following streams in the watershed: a 6 mile stretch of Bull Creek in Taney County; 1 mile of Beaver Creek in Taney County; 3.5 miles of Roark Creek in Taney County; and 3 miles of Swan Creek in Taney County.

Waters in the Arkansas portion of the watershed have all been designated for fish and wildlife protection, primary and secondary contact recreation, and domestic, agricultural, and industrial water supplies. Most of these use designations should be supported with the exceptions of 59.5 total miles of Yocum, Long, and Dry creeks and the upper sections of War Eagle and Brush creeks, tributaries to Kings River, not supporting primary contact (swimming). An additional 177 miles of streams were assessed as only partially supporting the aquatic life use. The inability of the streams to support their classified use designations is a result of high silt loads from agricultural practices, instream gravel removal, and road building activities and the associated high sediment and bacterial levels associated with these practices (ADPC&E 1996). Crooked River has been listed as the fifteenth most endangered river in the nation by American Rivers. The group listed degradation from extensive gravel mining as the main cause for the listing (American Rivers 1998). The majority of these streams, with the exception of Crooked River, flow into the Missouri portion of the watershed.

Bull Shoals Lake, Kings River, and Richland Creek, a tributary to the Kings River, have all been designated as Extraordinary Resource Water bodies by Arkansas Department of Pollution Control and Ecology (ADPC&E), and are subject to stricter regulations concerning pollution discharge and instream activities. Kings River and Richland Creek are also recognized as National Scenic Riverways (J. Wise, ADPC&E, pers. comm.).

CHEMICAL QUALITY, CONTAMINATION, AND FISH KILLS

The USGS has implemented a broad scope National Water Quality Assessment (NAWQA) study on 20 study units throughout the United States. Implementation of the NAWQA study in the Ozark Plateau Study Area, which includes the White River watershed, began in 1991. The objectives of the NAWQA Program are to: describe current water quality conditions for a large part of the nation's freshwater streams, rivers, and aquifers; describe how water quality is changing over time; and improve understanding of the primary natural and human factors that affect water quality conditions. Large amounts of information concerning water quality have and will continue to come from this effort and some of this information has been presented in this document.

One of the areas of the largest concentration of nitrite plus nitrate and phosphorus was found at the sample location directly below Table Rock Dam. This site was considered an integrator site, because land uses above the sample location were of two major types, urban and agricultural. Water quality samples reflect the larger concentrations of nitrite plus nitrate and phosphorus that would be expected with the agricultural and urban development that has occurred in the watershed above this point (USGS 1995).

Increases in discharge caused by precipitation runoff in an unregulated (agricultural) basin with primarily nonpoint sources of nitrite and nitrate generally result in an initial increase in nitrite plus nitrate concentrations caused by washoff of available material followed by decreasing concentrations as dilution occurs. The magnitude of concentration will depend on the availability of nitrite and nitrate in the basin, which is directly related to land use.

NAWQA sample sites within forested areas had little to no increases in nitrite plus nitrate concentrations with increasing discharge and virtually no dilution effect. Sample sites within agricultural land use areas had definite increases in concentration with increasing discharge followed by dilution. These patterns may hold true in the White River watershed considering the agricultural land use in the western and southern portion of the watershed and the more forested areas associated with the central and eastern portions of the watershed (USGS 1995).

Hypolimnetic water releases from the three large hydropower dams in the watershed have greatly impacted the entire White River system from below Beaver Dam to the confluence with the Mississippi River. Colder than normal temperatures and low dissolved oxygen levels in these releases, mainly in the summer and fall, have been blamed for stressing fish and are thought to have been the cause of fish kills in some tailwaters (Spotts 1991).

Temperature stress and low dissolved oxygen or other water quality problems associated with hydropower generation have been associated with at least 16 fish kills in the Bull Shoals tailwaters (Spotts 1991). Much work has taken place between the state agencies responsible for the fish in these waters and the agencies managing the dams. Cooperative efforts are ongoing, in both states, to increase oxygen levels in tailwater reaches while maintaining adequate hydropower production. Emergency plans are in place should dissolved oxygen levels reach excessive lows.

The tailwaters of the three large hydroelectric dams in the watershed support coldwater fisheries of major economic proportion. Concern has developed about the future of these fisheries stemming from the concern over water quality and its close association with the increased human population growth and the growth of the poultry industry in the watershed.

Raw groundwater in the Missouri portion of the watershed is considered good, 300-499 total dissolved solids (tds), to excellent, fewer than 300 tds. Surface water is typically a calcium-magnesium-bicarbonate type (MDNR 1995).

Water quality trend data from 1970-1989 in the Arkansas portion of the watershed indicate a decrease in dissolved oxygen levels for one of the four stations (lower Kings River) influencing Missouri waters. One of three stations sampled (lower Kings River) for total nitrogen showed an upward trend between 1984 and 1989. No trends developed at other stations. One of four stations (White River below Beaver Lake) showed an upward trend for total nitrites between 1978 and 1989, while no trends developed from three other stations. Samples showed a downward trend in total ammonia at sites both above and below Beaver Lake between 1979 and 1989. No significant trends appeared for total phosphorus for this period. Fecal coliform data showed a downward trend at two of the three stations (above Beaver Lake and lower Kings River) from 1975 to 1987, with no significant trend developing at the other sites. The increasing upwards trends are thought to be associated with increased livestock production and an increasing human population. Downward trends are associated with increased efficiency of wastewater treatment facilities (USGS 1992).

MDC collects contaminant samples of fish flesh from several locations in the watershed annually, and the Missouri Department of Health (MDOH) analyzes the samples for several kinds of contaminants and includes them in an assessment of statewide consumption advisories. There are no current health advisories for fish consumption in the watershed (MDOH 1998). No fish consumption advisories are in place for the Arkansas portion of the watershed (Wise, J., ADPC&E, pers. comm.) A 1992-1995 NAWQA study of biological-tissue sampling, which included the White River watershed, found no levels of organic compounds that exceeded any health criteria or standards. This information showed that organic compounds do not pose a widespread or persistent problem in the watershed (USGS 1997).

There have been thirty-four confirmed pollution incidents in the Missouri portion of the watershed since 1978 (Table WQ02). Fish kills have been confirmed from nine of these incidents totaling 8,028 fish. The largest recorded fish kill occurred in Fall Creek on June 18, 1998 when a broken sewage main released raw sewage into the creek, killing an estimated 4,118 fish. Sewage has been the leading cause of pollution events and fish kills in the watershed; 11 pollution events and 3 confirmed fish kills, followed by gasoline; 7 pollution events and no known fish kills. The majority (N=28) of the pollution events have been recorded from Stone and Taney counties. Table Rock Lake has the most pollution events for any body of water (N=9), followed by Lake Taneycomo (N=8), Bull Creek (N=4), and Beaver and Fall creeks (N=3 each).

Problem fish kill areas in the Arkansas portion of the watershed have been associated with sewage overflows from Fayetteville, AR which have been responsible for repeated fish kills in Beaver Lake. Major improvements have taken place in this WWTF which have reduced sewage pollution to Beaver Lake. Low dissolved oxygen levels and temperature stress from releases below Bull Shoals Lake have also been responsible for at least 16 documented fish kills (Spotts 1991). Land applied poultry litter has also been blamed for local fish kills (Shirley 1992).

WATER USE

The majority of the water use in the watershed is domestic (Table WQ03). Figure WQ02 clearly shows the large concentration of wells associated with the Branson/Table Rock Lake area. Most water from this area is groundwater drawn from the Ozark aquifer. The City of Branson is the only town in the Missouri portion of the watershed that uses the White River for a water supply. The City of Branson has a surface water intake on Lake Taneycomo and eight deep wells that meet water supply needs.

The rapid growth of the Branson/Table Rock area has raised concerns regarding the future groundwater quality and availability in the watershed. Because most of the increased water demand occurs during the summer tourist season, water levels are lowered substantially in the summer, but recover during the winter. Data, from summer surveys conducted from 1987-89 (Imes 1991), revealed several cones of depression in the Ozark aquifer, one on either side of Lake Taneycomo, one centered in the area just west of Branson, and one below Hollister. Data from March of 1989 indicated that groundwater levels had returned to pre-development elevations. A groundwater model developed for the area was used to predict whether or not these trends have any potential for long-term impact on water availability for the region. The model predicted that present cones of depression will deepen over time, and very small cones of depression are predicted to develop for Forsyth, Rockaway Beach, and Taney County Public Water Supply District #2. These drawdown levels should not threaten the capability of deep wells, and adequate water should be available in the area through 2010 (Imes 1991).

Some concerns about the amount and quality of the water that flows out of Table Rock Lake to the public water supply wells for the City of Branson have been raised. A study by Hester (1993) found that 11 million gallons of water per day were estimated to flow from Table Rock Lake to these wells and that the water quality of Table Rock Lake has a large influence on the raw groundwater supply of Branson. Hester (1993) also found that as water use increases from the Branson supply wells, the outflow of water from Table Rock Lake to these wells will also increase.

The Springfield Plateau and the southwestern Ozark Plateau regions are two of the regions with the largest livestock water use in the state. This region, including the watershed, is characterized by large cattle and horse populations which require a great deal of water on a per capita basis. Poultry production may also account for major livestock water use in Barry County. The USGS estimates that water use for non-confined livestock is 100% consumptive (MDNR 1996b).

Roaring River Fish Hatchery uses between 11 and 12 million gallons of water per day (mgal/day) from Roaring River Spring for hatchery production and maintenance (Dean, J., MDC, pers. comm.). Dye traces done in the area have shown that the losing stretch of Dry Hollow has a direct recharge to the spring. Also numerous, large, sinkholes located along Greasy Fault allow direct recharge to the spring, and one seven-mile stretch of an unnamed stream flows directly into a cave, which also recharges directly to Roaring River Spring (Rogers, M., MDNR, pers. com.).

The Roaring River Spring recharge area also includes the upper portion of Flat Creek, a separate drainage included in the James River watershed. Surface water in the Flat Creek drainage flows northeast, while the groundwater below the drainage flows southeast to Roaring River Spring.

RECREATIONAL USE

The White River was once considered one of the finest float streams in the U.S., and smallmouth bass fishing on the river was unequaled. Today none of the White, in Missouri, remains in its natural, free flowing state. The larger tributary streams of the watershed (Swan Creek, Bull Creek, Beaver Creek, and Roaring River) still provide canoeing and wade fishing opportunities. About 21 miles of Swan Creek are considered navigable for the purpose of floating. In normal water years Swan Creek is considered mainly a wade-and-float fishing stream, but heavy rains can bring it up rapidly and give it characteristics of a whitewater stream. Bull Creek is similar in size and drainage to Swan Creek, but it is less floatable than Swan Creek. Roaring River and Beaver Creek are other floatable streams in the watershed. Summer floats on Beaver Creek should start near or below Bradleyville (Hawksley 1989).

The White River watershed has a large recreational value both in Missouri and Arkansas. The area attracts a large number of people annually and water-related recreation is a substantial reason for the watershed's popularity. A study of recreational use conducted by Weithman (1991) found that the White River in Missouri, and its smaller tributaries, which make up all of the flowing waters in the watershed, had an estimated angler effort (days fished) that ranked it between thirteenth and sixteenth statewide. The survey was conducted annually from 1983 to 1988 on 19 streams statewide. A survey conducted by Bachant et al (1982) found the White River ranked eleventh statewide in recreational worth (participants were asked to rank, in descending order, the ten watersheds they thought to have the most recreational value) and predicted the watershed to drop to seventeenth statewide in the future (participants were asked to rank the ten watersheds they felt would become the most important in the future). The study found that the watershed ranked twelfth statewide when participants were asked to rank recreational value of the watersheds in their local area.

Roaring River is one of four managed public trout parks in the State of Missouri. Roaring River "trout park" is in Roaring River State Park. Land surrounding the stream is managed by MDNR, while the hatchery and fishery are managed by MDC. Daily trout tags are required to fish in the park. Roaring River ranked second, among the four trout parks, in daily tag sales for the 1996 season with 120,463 tags sold (Weithman S., MDC, pers. comm.). Roaring River from below Roaring River State Park to Table Rock Lake is a Trout Management Area.

Lake Taneycomo is another state Trout Management Area. Lake Taneycomo ranked second, among Missouri trout waters, in angler effort (days fished) lead only by the combined angler effort numbers from the four trout parks. Taneycomo angler effort for the period (1983-1988) was highest in 1986 (357,246 days fished). Additional angler surveys are currently underway.

A survey of reservoir use showed that, bi-annually from 1988-1994, Table Rock and Bull Shoals lakes ranked first and second, respectively, for recreational visitor hours, as compared to other USCOE lakes throughout Missouri. Recreational use at Table Rock varied from 30 to almost 40 million visitor hours annually. Recreational use at Bull Shoals varied between 15 to 25 million visitor hours annually.

A similar use study conducted by Weithman (1991), which used angler effort as a gage and included both USCOE and non-USCOE lakes, showed different recreational use rankings. Table Rock Lake was the most heavily fished lake in the watershed and ranked either second or third, statewide, throughout the period. Lake Taneycomo ranked fourth statewide from 1983-1986, but fell to fifth statewide in 1987 and sixth statewide in 1988. Bull Shoals Lake ranked eighth from 1983-1985, seventh in 1986 and 1988, and sixth in 1987.

Missouri STREAM TEAMs are a group of volunteers who assist in the protection of streams throughout the state. STREAM TEAMs are supported by MDC, MDNR, and the Conservation Federation of Missouri. Participants range from single individuals, to grade school classes, to organized advocacy groups. Their efforts include litter clean-up, water chemistry and macroinvertebrate sampling, tree planting for bank stabilization, and stream inventories. The STREAM TEAMs programs and citizen awareness about stream issues have been a growing and important facet of protection and enhancement of state waters. These organizations will continue to play ever important roles in future stream issues.

Arkansas also has a STREAM TEAM program coordinated by the AG&FC. The program was started in early 1997 and there were 190 STREAM TEAMS as of Sept. 1, 1998. Supporting agencies include: AG&FC, ADPC&E, NRCS, USGS, USFS, Arkansas Department of Parks and Tourism, local Soil and Water Conservation districts, Smallmouth Bass Alliance, Arkansas Cattleman's Association, Arkansas Chapter of the American Fisheries Society, and Sierra Club (Filipek, S., AG&FC, pers. comm).

POINT SOURCE POLLUTION

Point sources are those which discharge wastewater to waters of the state and must obtain National Pollution Discharge Elimination System (NPDES) permits. The MDNR issues and monitors these permits throughout Missouri, and the Springfield Regional Office is responsible for the area including the Missouri portion of the White River watershed. Permits vary widely including stormwater runoff, subdivisions, mobile home parks, concentrated animal feeding operations, limestone quarries, municipal sewage treatment plants, building and road construction, etc. There are eight municipal WWTFs in the Missouri portion of the watershed (Table WQ04, Figure WQ03) that land apply 3,440 tons of sludge annually. The Washburn WWTF lies outside the watershed, but within the known Roaring River Spring recharge area and produces an additional 9.7 tons of sludge annually. As of September 15, 1998 there were 251 NPDES permits granted in the watershed (Figure WQ04). Many of these are associated with the Branson/Table Rock Lake area and have the potential to negatively affect receiving streams and ground water.

Public and private sources produce 4,069 tons of domestic sludge annually which is land applied throughout the watershed. Wilderness Safari wastewater discharge has had a noted negative impact on one mile of Fall Creek and chlorine toxicity problems have been caused in 0.5 miles of Prairie Creek from the Ava WWTF (MDNR 1995).

There are thirty-three NPDES permitted point sources in the Arkansas portion of the watershed. Twenty of these are located with the potential to impact Missouri waters. There are 11 municipal WWTFs in the Arkansas portion of the watershed (Table WQ04; Figure WQ03). The city of Fayetteville, AR recently upgraded its municipal sewage treatment plant and diverted portions of its discharge from Beaver Lake to the Illinois River basin which flows into Oklahoma. These changes have helped to reduce the amount of sewage effluent that flows to Beaver Lake. Beaver Lake still receives some sewage from smaller discharges associated with development of the surrounding area (Shirley 1992).

The Toxic Release Inventory (TRI) contains detailed information about parties that release, store, or process toxic materials such as heavy metals and pesticides. There are 23 toxic release sites in hydrologic unit 11010001 and 13 sites in hydrologic unit 11010003. There are 50 hazardous waste sites in hydrologic unit 11010001 and 50 hazardous waste sites in hydrologic unit 11010003. The Environmental Protection Agency (EPA) keeps a current database of these sites. The EPA also tracks Superfund sites, sites that are candidates or have been identified for cleanup of toxic waste problems. There is one superfund site in the watershed located in hydrologic unit 11010003, near Omaha, Arkansas.

The James River has the largest point source impact on Table Rock Lake. The James River provides relatively large loads of nitrogen and phosphorus to the James River Arm of Table Rock Lake. The James River Arm commonly has higher levels of suspended algae, and has a more productive fishery than other parts of Table Rock Lake (MDNR 1995). The Springfield Southwest WWTF discharges 42.5 million gallons per day to the James River and has been estimated to deliver 30 percent of the total phosphorus load to Table Rock Lake (USGS 1995). Information concerning water quality of the James River basin can be found in the James River Inventory and Management Plan (Kiner and Vitello 1997).

The largest point source concern in the Bull Shoals region of the watershed is the Ava waste water discharge to Prairie Creek in the Beaver Creek subwatershed. Discharge from the Ava WWTF shows evidence of chlorine toxicity in about 0.5 miles of Prairie Creek. The city of Forsyth began operating a new WWTF in 1997 which should help to correct localized problems associated with the city formerly being unsewered (MDNR 1995) . The large population increases in and near Branson formerly caused an overburdening of the city's WWTF. This problem should now be minimized with the opening of the Cooper Creek WWTF.

State regulations require all existing wastewater discharges to Lake Taneycomo and its immediate tributaries, including Bull Creek, greater than 25,000 gallons per day and all new wastewater discharges, regardless of size, to limit the total phosphorus concentration of the discharge to no

more than 0.5 mg/l, in an effort to reduce algae growth. Similar phosphorus limit regulations are being considered for Table Rock and Bull Shoals lakes. Any future facilities have been advised of these recommendations. The Springfield Southwest WWTF is considering installing a phosphorus removal system (George, R., MDNR, pers. comm.).

NONPOINT SOURCE POLLUTION

Seepage from individual septic systems throughout the watershed, with a higher density near the Table Rock/Branson area, is thought to be a major source of nonpoint pollution, although this is unquantified. A water quality study conducted in Taney County (Aley 1982) sampled 75 springs and stream points. The study found optical brighteners, a chemical in laundry detergent and evidence of domestic sewage, in 80% of the springs and 58% of the stream points sampled. The evidence of domestic sewage was even more prevalent in developed areas, where 95% of the springs and 75% of the stream points sampled were positive for optical brighteners. Bacterial contamination of ground and stream waters probably occurs in areas adjacent to Taney County which have similar geology and development patterns (MDNR 1995). MDNR identified individual septic systems as the most significant water quality problem in Taney County (MDNR 1986b). Septic tanks were the fourth highest concern statewide as a source for groundwater contamination, causing bacterial, viral, and nitrate contamination (MDNR 1986b).

Soils with inadequate absorption qualities, including the majority of soils in the watershed, are the most common causes for failure of septic systems, and density of septic tank systems is the most important factor in determining potential for groundwater pollution (Kinter 1983). Diseases associated with septic tank fluids include typhoid, hepatitis, cholera, dysentery, and leptospirosis, which affect both humans and animals (Morris 1981). Reports indicate that the population of the watershed is growing most rapidly in rural areas with individual septic systems being the most common means of sewage treatment. In 1981, 80 to 90 percent of the homes in Taney and Stone counties had on-site septic systems (Morris 1981).

The EPA rates areas for potential of groundwater contamination based on the number of on-site septic systems per square mile. Figures from the 1980 census indicated that areas near Branson and adjacent to Table Rock Lake and Lake Taneycomo were considered high risk for groundwater contamination from failing septic systems. The EPA also considers areas that depend primarily on groundwater for home water supply and that are characterized by karst landforms as especially vulnerable to groundwater contamination (Morris 1981). A 1989 study in Christian County found that 50% of the groundwater samples taken from individuals' wells contained fecal coliform levels unsafe for human consumption (St. Clair 1989).

There are eighteen concentrated animal feeding operations (CAFOs) in the Missouri portion of the watershed that are permitted by or carry letters of approval from the MDNR (Table WQ05, Figure WQ03). The human population equivalent (PE) (the human population estimated to produce amounts of waste similar to that produced by a given number of animals) of these operations is 88,674, or equal to 50% the entire human population in the watershed. There are 22

permitted poultry CAFOs in the Roaring River Spring recharge area (Table WQ05, Figure WQ03) with a population equivalent of 113,988, or equal to 64% of the human population in the watershed. The total combined PE for the Missouri portion of the watershed and the recharge area is 147,809. The majority of these operations land apply wastes and have the potential to negatively affect the water quality in the watershed. NAWQA studies in the region have found that nitrite plus nitrate concentrations positively correlate to percent agricultural land use around sample sites, and median nitrite plus nitrate concentrations were generally higher in tested springs than in tested wells (USGS 1996). The Washburn WWTF is also in the Roaring River Spring recharge area. Water quality has been monitored by the USGS and MDC personnel for the past several years, and no significant trends associated with agricultural land use have developed. Hatchery manager Jerry Dean (MDC, pers. comm.) did indicate that aquatic plant growth, both in the spring and spring branch, has increased over the past several years. Hemsath (1992) lists Roaring River Spring as the main point source of pollution to the Roaring River subwatershed. Water quality monitoring should remain a high priority, and continuing inventories of pollution sources in the watershed should include the spring recharge area.

The Arkansas portion of the watershed also includes a large number of poultry producing operations (Table WQ06). Many of these are in the Kings River subwatershed and other areas that drain to the Missouri portion of the watershed. The ADPC&E regulates operations that store and land apply liquid waste and helps establish voluntary waste management plans for operations that land apply dry waste (Wise, J., ADPC&E, pers. comm.). Approximately 1.9 million metric tons of poultry manure were produced and land applied in the Arkansas portion of the watershed in 1991 (Shirley 1992). The poultry produced annually, in the counties making up the Arkansas portion of the watershed, have a human population equivalent of 6,365,225, or 36 times the entire 1990 human watershed population (Wise, J., ADPC&E, pers. comm.).

Conversations with MDNR and ADPC&E personnel indicate that a symbiotic relationship exists between CAFOs and other agricultural land use practices, although unquantified at this time. With an increased number of CAFOs, comes an increase in other agricultural practices, mainly clearing for additional pasture land and increased cattle numbers. CAFOs in Missouri that have more than 7,000 animal units are regulated by the MDNR. The regulations state that, depending on the number of animal units, a certain amount of vegetated land must either be owned or contracted for the spreading of manure, or the waste must be sold or contained in closed lagoons. The increased number of CAFOs in the watershed is related to a growing amount of land being converted to either pasture or crop land. Land application of litter has added to soil productivity and improved pasture and hay production. This combination of factors has lead to an unquantified increase in land clearing and cattle production (Parsons, G. and Kugler, V., MDNR; Wise, J., ADPC&E, pers. comm.).

Cattle on pasture are another potential nonpoint threat to the watershed's water quality. Cattle on pasture in the Missouri portion of the watershed are estimated to produce an amount of waste equal to that of 1.5 million people or over 8 times the human population of the entire watershed. Cattle numbers were estimated from county figures available from the Missouri Agricultural

Statistics Service (MASS) under the assumption that cattle were equally distributed throughout each county. This equal distribution was then applied to the percentage of each individual county lying within the watershed. The estimated number of cattle in the watershed was multiplied by the population equivalents (PE = 14 per 1,000 pounds for beef cattle and PE = 20 per 1,000 pounds for dairy cattle) and by .08, assuming the average weight of cattle is 800 pounds (MASS 1997). Runoff of waste from pastures, damage to riparian areas, and streambank trampling are some of the problems associated with cattle, although the effects of this type of non-point pollution are very difficult to quantify. Cattle waste has the potential to add high levels of fecal bacteria, nitrates, and phosphates to both surface and groundwater. Cattle with access to streams and streambanks can damage riparian areas and trample streambanks, leading to increased bank erosion and sedimentation, increased water temperatures, and decreased filtering properties in riparian areas. These have the potential to affect water quality and aquatic life and possibly affect human health. The large amount of waste produced by cattle and poultry operations is a major source of nutrients that waters receive as nonpoint pollution (USGS 1996).

There are three inactive landfills in the Missouri portion of the watershed, one near Kimberling City, in Stone County, one near Branson in Taney County, and one near Shell Knob, in Barry County (MDNR 1998c). There is one transfer station located near Branson in Taney County (MDNR 1998d).

The watershed is primarily forested and very little land is cultivated, hence soil erosion rates are low and problem areas are localized. Most soil erosion is associated with land clearing for development. Lake Taneycomo has incurred substantial sedimentation since its impoundment. From its creation in 1913 to 1958, 42% of Lake Taneycomo filled with sediment, and from 1958 to 1987, an additional 7% of the lake has filled (Berkas 1989). Soil erosion associated with land clearing for development is one of the largest nonpoint source problems in this area of the watershed (MDNR 1995).

The major threats to the water quality of the streams in the Arkansas portion of the watershed are sedimentation from sand and gravel mining, streamside agriculture and cattle grazing, and land application of poultry waste (Shirley 1992). Northwestern Arkansas is a region of some of the highest poultry production rates in the United States. Land applied litter from these operations has the potential to contaminate both ground and surface water. Localized fish kills and widespread water quality problems have been attributed to runoff from poultry waste (Shirley 1992). Nitrate levels measured from this region are typically high (ADPC&E 1996).

The EPA rates the health of individual watersheds based on several different factors. Beaver Lake (11010001) ranks 3 (less serious problems-low vulnerability) on a scale of 1 to 6, with 1 being the best possible rank. The health of Bull Shoals Reservoir (11010003) ranks 1 (better water quality-low vulnerability) based on the same factors.

Table WQ01. Beneficial use classifications for streams in the Missouri portion of the White River watershed.

Stream	Mi.	From	To	County	Beneficial use*
Barbers Creek	3.0	mouth	25N 19W 08	Christian	LW,AL
Barret Hollow	1.5	mouth	22N 15W 01	Ozark	LW,AL
Barren Fork	7.0	mouth	23N 14W 10	Ozark	LW,AL
Bear Creek	3.0	mouth	24N 16W 01	Ozark	LW,AL
Bear Creek	4.0	mouth	24N 21W 18	Taney	LW,AQ,WB,BC
Bear Creek	6.0	24N 21W 18	25N 22W 36	Taney	LW, AQ, WB, BC
Beaver Creek	44.5	mouth	27N 17W 23	Taney	LW,AQ,WB,BC,CL
Trib. Beaver Cr.	1.0	mouth	24N 18W 23	Taney	LW,AQ
Beaver Creek	2.0	27N 17W 23	27N 17W 10	Douglas	LW,AQ
Bee Creek	1.6	mouth	23N 21W 17	Taney	LW,AQ,CD
Bee Creek	3.5	mouth	21N 20W 05	Taney	LW,AQ,WB
Bennett Hollow	2.0	mouth	23N 15W 13	Ozark	LW,AQ
Big Creek	5.0	mouth	23N 17W 25	Taney	LW,AQ,WB
Big Hollow	3.2	mouth	22N 21W 23	Taney	LW,AQ
Bray Hollow	1.0	mouth	23N 15W 27	Ozark	LW,AQ
Bright Hollow	2.0	mouth	25N 20W 32	Taney	LW,AQ
Brushy Creek	6.0	mouth	HWY. 125	Taney	LW,AQ
Brushy Hollow	1.0	mouth	23N 15W 25	Ozark	LW,AQ
Bull Creek	5.0	mouth	24N 21W 34	Taney	LW,AQ,WB,BC,CD,IR
Bull Creek	17.5	24N 21W 34	26N 20W 33	Taney	LW,AQ,WB,BC,CL,IR
Bull Creek	3.0	26N 20W 33	26N 20W 22	Christian	LW,AQ,WB
Camp Creek	1.0	mouth	25N 21W 16	Christian	LW,AQ
Cane Creek	3.0	mouth	23N 18W 28	Taney	LW,AQ,CL
Caney Creek	4.0	mouth	24N 17W 12	Taney	LW,AQ,WB
Cedar Creek	1.0	22N 19W 02	22N 18W 06	Taney	LW,AQ
Clayton Hollow	1.0	Mouth	24N 18W 03	Taney	LW,AQ
Coon Creek	5.4	mouth	22N 21W 24	Taney	LW,AQ
Cooper Creek	0.4	mouth	22N 21W 07	Taney	LW,AQ
Cooper Creek	1.6	22N 21W 06	22N 21W 07	Taney	LW,AQ
Cowskin Creek	5.0	mouth	27N 16W 33	Douglas	LW,AQ
Cowskin Creek	3.0	HWY. 14	27N 16W 21	Douglas	LW,AQ
Dry Hollow	2.5	mouth	24N 16W 34	Ozark	LW,AQ
E. Fork Bull Cr.	3.0	mouth	26N 20W 23	Christian	LW,AQ
Elbow Creek	1.0	mouth	22N 18W 27	Taney	LW,AQ
Fall Creek	1.0	mouth	22N 22W 11	Taney	LW,AQ
Fall Creek	3.6	22N 22W 11	23N 22W 28	Taney	LW,AQ
Fox Creek	0.5	mouth	21N 20W 27	Taney	LW,AQ
Goldsbarry Hol.	3.0	mouth	23N 16W 31	Ozark	LW,AQ
Gulley Spr. Cr.	3.5	mouth	21N 14W 05	Ozark	LW,AQ
Kings River	2.0	mouth	state line	Taney	LW,AQ,WB,BC
L. Beaver Cr.	9.0	mouth	26N 18W 36	Taney	LW,AQ,WB,BC,IR
L. Beaver Cr.	4.0	26N 18W 30	26N 17W 17	Douglas	LW,AQ
L. North Fork	5.0	mouth	24N 16W 36	Ozark	LW,AQ,CL

Table WQ01. Beneficial use (continued).

Stream	Mi.	From	To	County	Beneficial use*
L. North Fork	6.0	24N 16W 36	24N 16W 03	Ozark	LW,AQ,CL
Lick Creek	1.0	mouth	22N 16W 32	Ozark	LW,AQ
Little Creek	5.0	mouth	24N 15W 17	Ozark	LW,AQ
Trib. Little Cr.	1.0	mouth	24N 15W 18	Ozark	LW,AQ
Long Run	1.5	mouth	23N 16W 27	Ozark	LW,AQ
Ludecker Hol.	1.5	mouth	23N 14W 04	Ozark	LW,AQ
McVay Branch	1.5	mouth	21N 16W 03	Ozark	LW,AQ
Morris Hollow	1.5	mouth	22N 16W 17	Ozark	LW,AQ
N. Fk. Spring Cr.	1.0	mouth	22N 14W 18	Ozark	LW,AQ
Otter Creek	2.0	mouth	24N 16W 22	Ozark	LW,AQ
Piney Creek	3.0	mouth	23N 25W 22	Stone	LW,AQ
Pond Fork	2.0	mouth	23N 16W 33	Ozark	LW,AQ
Pond Fork	7.0	23N 16W 23	Taney Line	Ozark	LW,AQ
Roaring River	7.0	mouth	22N 27W 34	Barry	LW,AQ,WB,BC,CD
Roark Creek	3.0	mouth	23N 22W 36	Taney	LW,AQ,WB,BC,CD
Roark Creek	4.0	23N 22W 15	23N 22W 15	Taney	LW,AQ,WB,BC
S.Fk.Spring Cr.	1.0	mouth	22N 14W 19	Ozark	LW,AQ
S. Spring Creek	5.0	mouth	25N 16W 23	Douglas	LW,AQ
Shoal Creek	2.0	mouth	22N 17W 32	Taney	LW,AQ,WB,CD
Short Creek	2.9	mouth	22N 21W 30	Taney	LW,AQ
Short Creek	0.9	22N 21W 30	22N 21W 36	Taney	LW,AQ
Silver Creek	1.6	mouth	23N 21W 01	Taney	LW,AQ
South Fork	4.5	mouth	24N 15W 25	Ozark	LW,AQ
Surratt Creek	1.0	mouth	25N 19W 26	Christian	LW,AQ
Swan Creek	29.5	mouth	26N 18W 04	Taney	LW,AQ,WB,BC,CL,IR
Swan Creek	2.0	26N 18W 04	27N 18W 34	Christian	LW,AQ
Table Rock trib.	2.5	mouth	22N 25W 03	Barry	LW,AQ
Turkey Creek	2.0	mouth	22N 21N 16	Taney	LW,AQ,BC,CL
Turkey Creek	4.0	22N 21W 16	22N 21W 04	Taney	LW,AQ
Turkey Creek	2.0	mouth	22N 16W 22	Ozark	LW,AQ
Turkey Creek	9.0	mouth	24N 15W 15	Ozark	LW,AQ
W. Fk. Big Cr.	3.0	mouth	22N 17W 03	Taney	LW,AQ
W. Fk. Bull Cr.	3.0	mouth	26N 20W 08	Christian	LW,AQ
W. Fk.Roark Cr.	3.0	23N 22W 15	23N 22W 07	Taney	LW,AQ,IR
Woods Fork	5.5	mouth	25N 21W 03	Christian	LW,AQ

*Beneficial use= LW= livestock and wildlife watering, AQ= protection of warmwater aquatic life and human health fish consumption, CL= coolwater fisheries, CD= coldwater fisheries, WB= whole body contact recreation, BC= boating and canoeing, IR= irrigation.
Source: MDNR (1996b).

Table WQ02. Fish kill and pollution incident summary for the Missouri portion of the White River watershed, 1977 to August 1998.

Water Body	Date	County	Number killed	Est. value($)	Cause/Source
Roaring River Spring	07-29-85	Barry	50		Municipal
Table Rock Lake	05-17-95	Barry	100		Natural
Bull Creek	01-19-90	Christian			Gravel removal
Beaver and Cowskin creeks	02-28-83	Douglas			Trash in creeks
Beaver Creek	06-20-78	Ozark			Gravel removal
Hunter Creek	06-21-78	Ozark			Landfill refuse
Table Rock Lake	12-18-78	Stone			Gasoline
Table Rock Lake	07-24-87	Stone			Gasoline
Table Rock Lake	05-11-88	Stone	150	1,209.00	Unknown
Table Rock Lake	04-21-93	Stone	1,000+		Parasites
Table Rock Lake	08-17-95	Stone	NA		Sewage
Table Rock Lake	09-24-96	Stone	NA		Gasoline
Bull Creek	04-08-81	Taney	250		Disease
Lake Taneycomo	04-26-82	Taney			Gasoline
Lake Taneycomo	03-31-83	Taney			Gasoline
Blair Branch	01-21-85	Taney			Industrial chemicals
Beaver Creek	06-26-86	Taney			Sewage
Fall Creek	08-06-86	Taney			Sewage
Lake Taneycomo	08-18-87	Taney			Gasoline
Lake Taneycomo	05-30-92	Taney			Sewage
Table Rock Lake	06-25-92	Taney			Disease
Emory Creek	05-18-93	Taney			Drilling fluid
Roark Creek	05-19-93	Taney			Quick foam
Bear Creek	08-03-93	Taney			Other
Lake Taneycomo	10-06-93	Taney			Municipal
Bull Creek	08-17-94	Taney			Sewage
Table Rock Lake	09-14-94	Taney			Septic tank
Lake Taneycomo	10-17-94	Taney	100	736.50	Low dissolved oxygen
Lake Taneycomo	11-04-94	Taney			Calcium chloride
Turkey Creek	05-31-96	Taney	794	781.11	Dewatering
Lake Taneycomo	06-14-96	Taney	NA		Gasoline
Bull Creek tributary	08-17-97	Taney	NA		Sewage
Fall Creek	09-08-97	Taney	1,466	283.69	Sewage
Fall Creek	06-18-98	Taney	4,118	411.80	Sewage

Table WQ03. Water use in the White River watershed in million gallons/day (mgd).

Category	11010001 Beaver Lake (mgd)	11010003 Bull Shoals Lake (mgd)	Total (mgd)
Consumptive Use	11.28	4.44	15.72
Groundwater Withdrawals	5.87	6.27	12.14
Groundwater Withdrawals for Commercial Use	0.15	0.53	0.68
Groundwater Withdrawals for Livestock	2.39	0.53	2.92
Groundwater Withdrawals for Public Use	1.86	2.92	4.78
Population Served by Surface Water*	32.37	22.86	55.23
Population Served*	47.44	43.19	90.63
Population Served by Groundwater*	15.07	20.33	35.40
Self Supplied Withdrawals	0.95	2.11	3.06
Self Supplied Surface-water Withdrawals	0.00	0.00	0.00
Self Supplied Population*	12.13	32.23	44.36
Self Supplied Ground-water Withdrawals	0.95	2.11	3.06
Surface Water Withdrawals for Public Use	36.73	2.30	39.03
Surface Withdrawals	44.83	4.78	49.61
Surface Water Withdrawals for Livestock	7.65	2.23	9.88
Surface Water Withdrawals for Commercial Use	0.00	0.00	0.00
Withdrawals for Public Use	38.59	5.22	43.81
Withdrawals	50.70	11.05	61.75
Withdrawals for Livestock	10.04	2.76	12.80

* The unit of measure for population served is in thousands.
Source: USGS (1990).

Table WQ04. Municipal waste water treatment facilities in theWhite River watershed.

Site #	Name	Receiving Water	Location T R S	County	Sludge*	Flow (mgd)
			Missouri Facilities			
WW01	Ava	Prairie Creek	21N 25W 17	Douglas	58.0	0.45
WW02	Branson West	W. Fork Roark Creek	23N 23W 13	Stone	26.7	0.13
WW03	Kimberling City	Table Rock Lake	22N 23W 09	Stone	37.8	0.18
WW04	Cooper Creek	Lake Taneycomo	22N 21W 07	Taney	880.0	3.40
WW05	Branson	Lake Taneycomo	23N 21W 33	Taney	1525.0	5.30
WW06	Forsyth	Bull Shoals Lake	24N 20W 33	Taney	57.5	0.30
WW07	Hollister	Turkey Creek	22N 21W 09	Taney	835.0	3.20
WW08	Rockaway Beach	Lake Taneycomo	23N 21W 11	Taney	20.0	0.10
WW09[1]	Washburn	Fall Creek	22N 28W 28	Barry	9.7	0.004
TOTALS						
3449.7	**13.6**					
			Arkansas Facilities			
WW10	Berryville	Osage Creek	20N 25W 36	Carroll	NA	NA
WW11	Bull Shoals	White River	20N 15W 29	Marion	NA	NA
WW12	Cotter-Gassville	White River	19N 14W 32	Baxter	NA	NA
WW13	Eureka Springs	Leatherwood Creek	20N 26W 10	Carroll	NA	NA
WW14	Fayetteville	Beaver Lake	16N 29W 07	Washington	NA	NA
WW15	Flippin	Fallen Ash Creek	19N 15W 20	Marion	NA	NA
WW16	Green Forest	Long Creek	19N 23W 10	Carroll	NA	NA
WW17	Harrison	Crooked Creek	18N 20W 02	Boone	NA	NA
WW18	Huntsville	War Eagle Creek	17N 26W 27	Madison	NA	NA
WW19	West Fork	W. Fork White River	15N 30W 29	Washington	NA	NA
WW20	Yellville	Crooked Creek	18N 16W 10	Marion	NA	NA

*Dry tons per year.

[1]This facility is outside the watershed but within the Roaring River Spring recharge area.

Source: MDNR (1998b), ADPC&E (1996).

Table WQ05. Concentrated animal feeding operations (CAFOs) in the Missouri portion of the White River watershed.

Site #	County	Location T R S	Receiving Stream	Class*	Type**	Human PE***
AW01	Barry	22N 27W 35	Roaring River	II	PB	5,815
AW02[1]	Barry	22N 27W 30	Dry Hollow	II	PB	4,154
AW03[1]	Barry	21N 28W 12	Dry Hollow	II	PB	4,154
AW04	Barry	21N 25W 17	Table Rock Lake	II	PB	3,588
AW05[1]	Barry	22N 28W 25	Dry Hollow	II	PB	5,538
AW06[1]	Barry	22N 28W 35	Dry Hollow	II	TK	12,146
AW07[1]	Barry	21N 28W 12	Dry Hollow	IC	PB	10,000
AW08[1]	Barry	21N 28W 02	Dry Hollow	II	PB	2,048
AW09[1]	Barry	21N 28W 11	Dry Hollow	NP	PB	2,024
AW10	Barry	21N 27W 13	Roaring River	II	PB	4,154
AW11	Barry	21N 27W 07	Dry Hollow	II	PL	4,154
AW12[1]	Barry	22N 28W 26	Dry Hollow	II	PB	3,365
AW13[1]	Barry	22N 28W 33	Dry Hollow	II	PB	5,539
AW14	Barry	22N 27W 11	Roaring River	IC	PB	12,000
AW15[1]	Barry	22N 28W 26	Dry Hollow	II	PB	5,885
AW16	Douglas	27N 17W 14	Beaver Creek	NP	DM	1,200
AW17	Douglas	27N 16W 09	Cowskin Creek	NP	DM	2,160
AW18	Taney	22N 17W 14	Bull Shoals Lake	NP	DM	2,700
Watershed Total PE 88,674						
AW19[1]	Barry	22N 28W 16	Flat Creek	II	PB	2,769
AW20[1]	Barry	22N 28W 25	Flat Creek	IC	PB	11,368
AW21[1]	Barry	22N 28W 25	Flat Creek	II	PB	2,600
AW22[1]	Barry	22N 28W 13	Flat Creek	II	PB	4,500
AW23[1]	Barry	22N 28W 09	Flat Creek	II	PB	4,553
AW24[1]	Barry	22N 27W 19	Flat Creek	II	PB	3,000
AW25[1]	Barry	22N 27W 17	Flat Creek	NP	PB	1,846
AW26[1]	Barry	22N 28W 10	Flat Creek	II	PB	6,000
AW27[1]	Barry	22N 28W 10	Flat Creek	II	PB	4,154
AW28[1]	Barry	22N 28W 25	Flat Creek	II	TK	7,269
AW29[1]	Barry	22N 28W 16	Flat Creek	II	PB	5,538
AW30[1]	Barry	22N 28W 22	Flat Creek	II	PB	5,538
Recharge Total PE						**113,988**
Watershed + Recharge Total PE						**147,809**

*IC facilities house 1,000-2,999 animal units, II facilities house300-999 animal units, NP facilities house less than 300 animal units.

**Animal Types: PB= poultry broiler, TK= turkey, DM= dairy milker.

***Human population equivalent = the human population estimated to produce amounts of waste similar to that produced by a given number of animals.

[1]Indicates CAFOs within the Roaring River Spring recharge area (Figure WQ03).

Note: CAFOs AW01-AW18 are in the White River watershed and AW19-AW30 are not in the watershed but are within the Roaring River Spring recharge area. Source: MDNR (1998b).

Table WQ06. Average number of poultry animals for the Arkansas counties that contain portions of the White River watershed.

County	Commercial Table Leg*	Broilers*	Hatchery Suppliers*	Turkeys*
Baxter	-	354,310	-	587,826
Benton	137,758	22,438,793	134,655	954,348
Boone	13,793	3,686,897	35,172	567,826
Carroll	235,690	7,544,138	18,103	1,615,217
Madison	-	7,242,069	68,793	350,435
Marion	-	-	3,103	576,826
Newton	-	-	3,103	-
Washington	312,931	2,040,690	192,069	1,362,174
Total by Category	700,172	43,306,897	454,988	6,014,652
Human PE**	42,000	2,598,413	116,021	3,608,791
TOTALS		Number		50, 476,709
		Total PE**		6,365,225

*Averages were figured by taking the total annual production and dividing by the average number of flocks a grower raises annually. Chickens average 5.8 flocks produced annually, and turkeys average 2.3 flocks produced annually.
**Human population equivalent = the human population estimated to produce amounts of waste similar to that produced by a given number of animals.
Source: Wise, J., ADPC&E, pers. comm.

Figure WQ01. Known coldwater streams in the Missouri portion of the White River watershed.

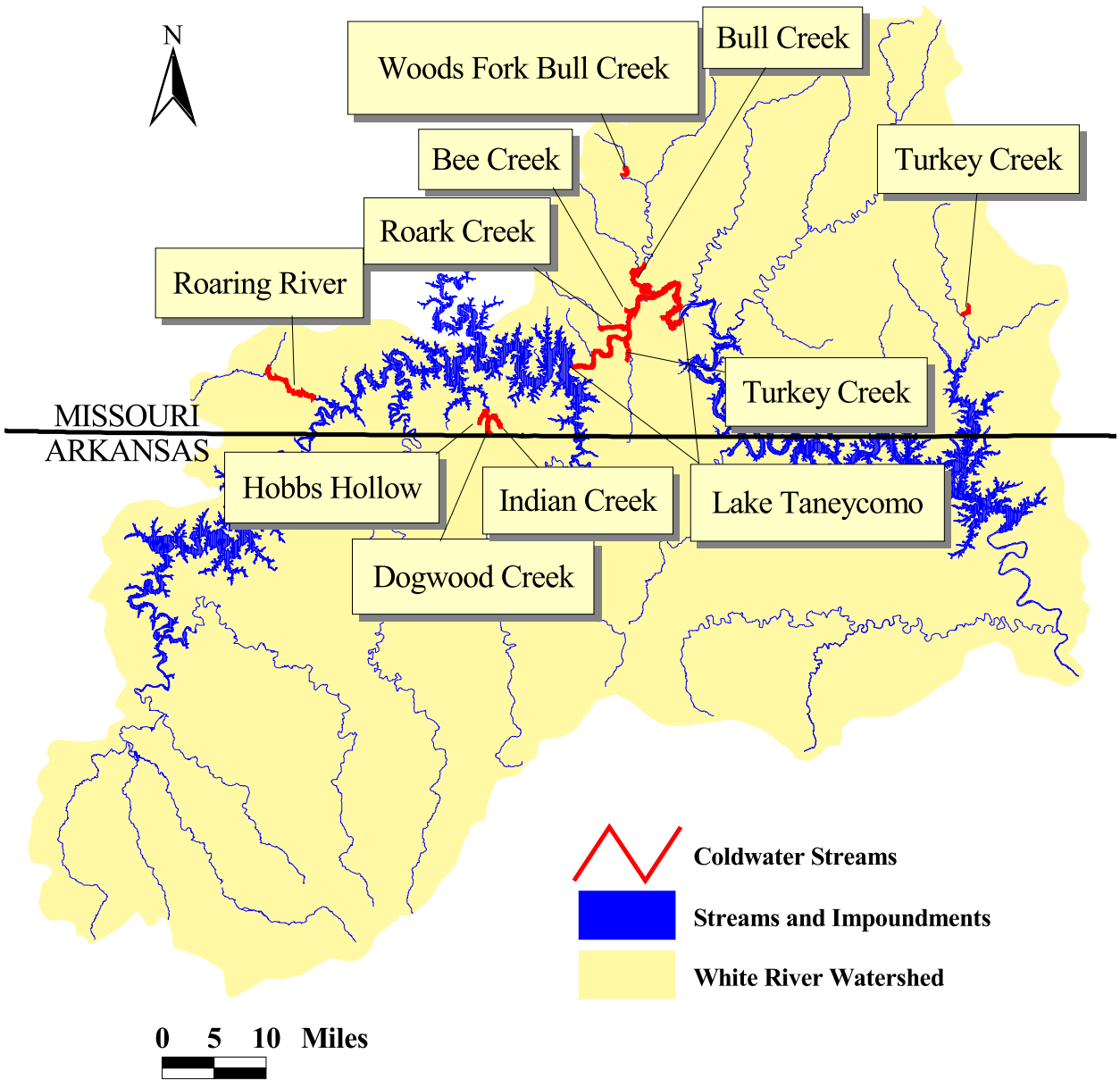


Figure WQ02. Permitted wells in the Missouri portion of the White River watershed.

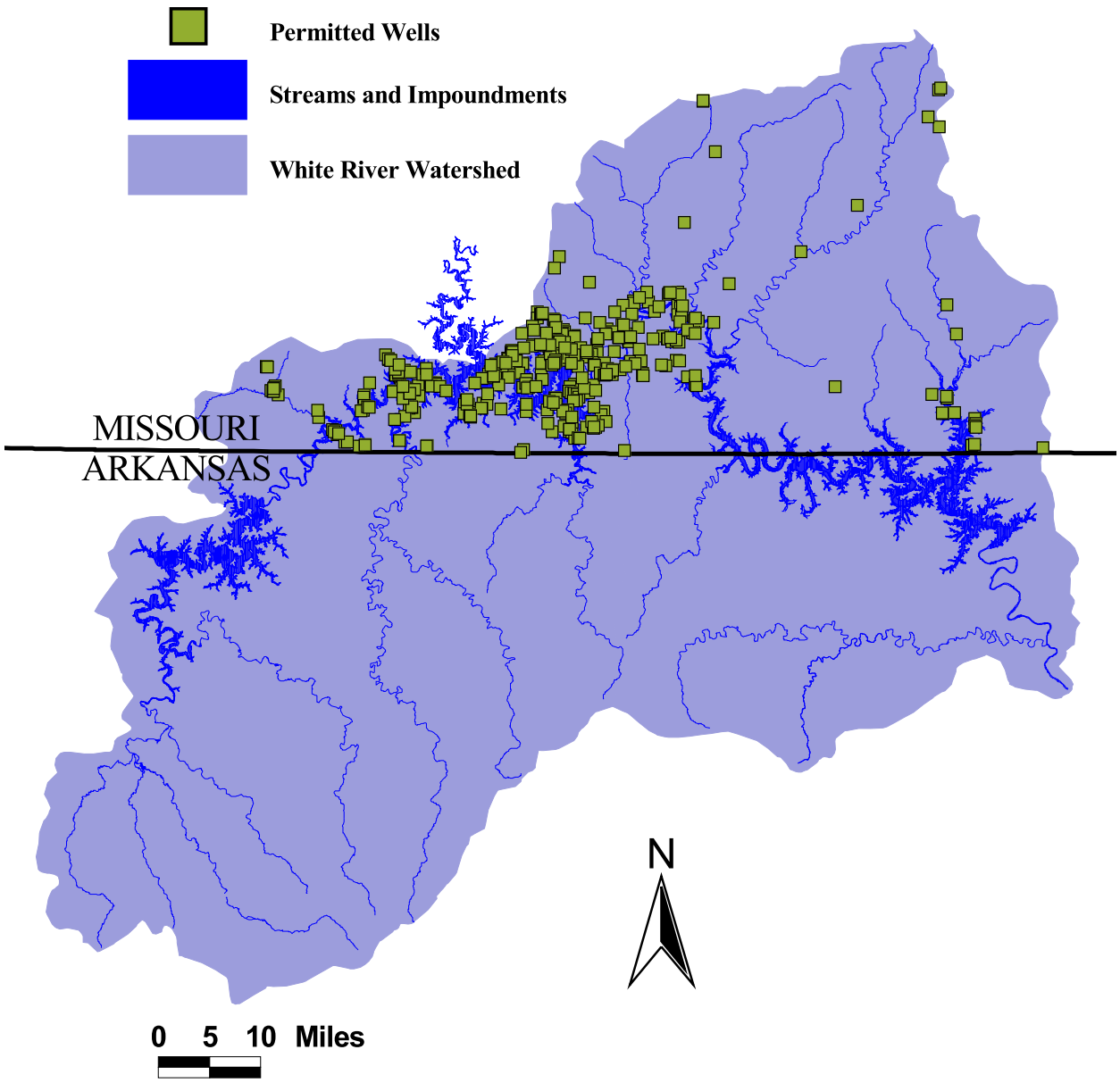
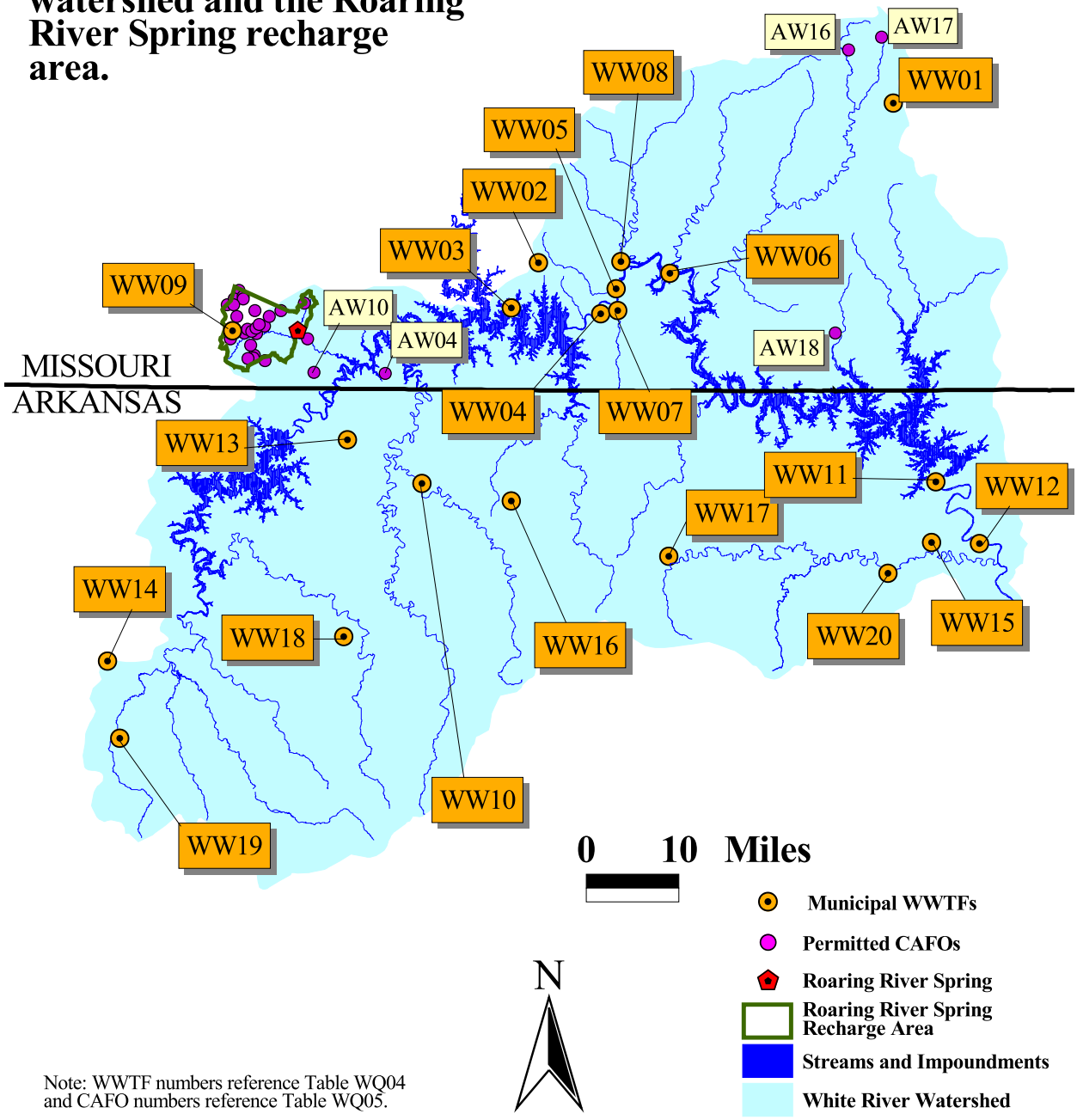
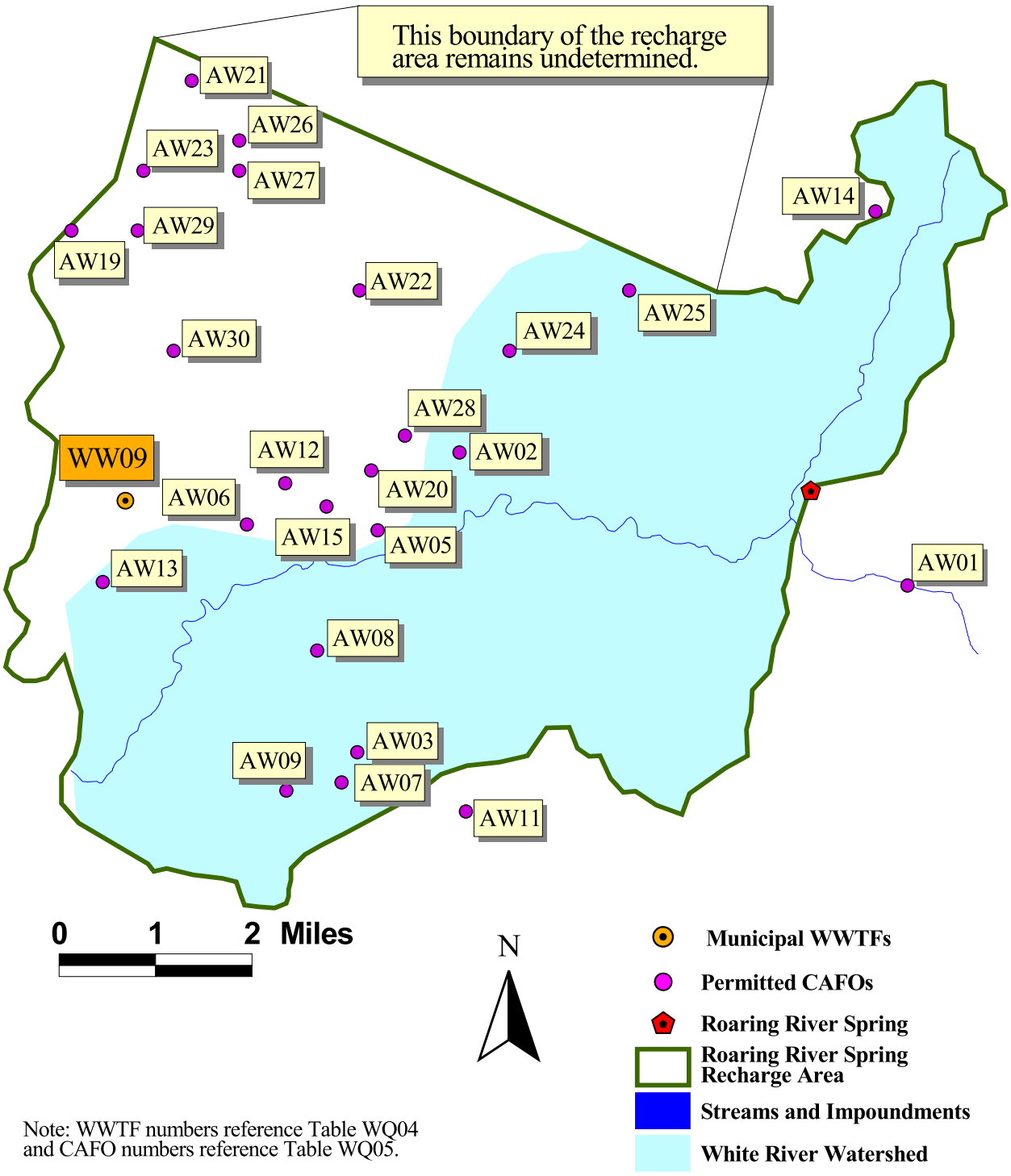


Figure WQ03. Municipal Waste Water Treatment Facilities (WWTFs) and permitted Missouri Concentrated Animal Feeding Operations (CAFOs) in the White River watershed and the Roaring River Spring recharge area.

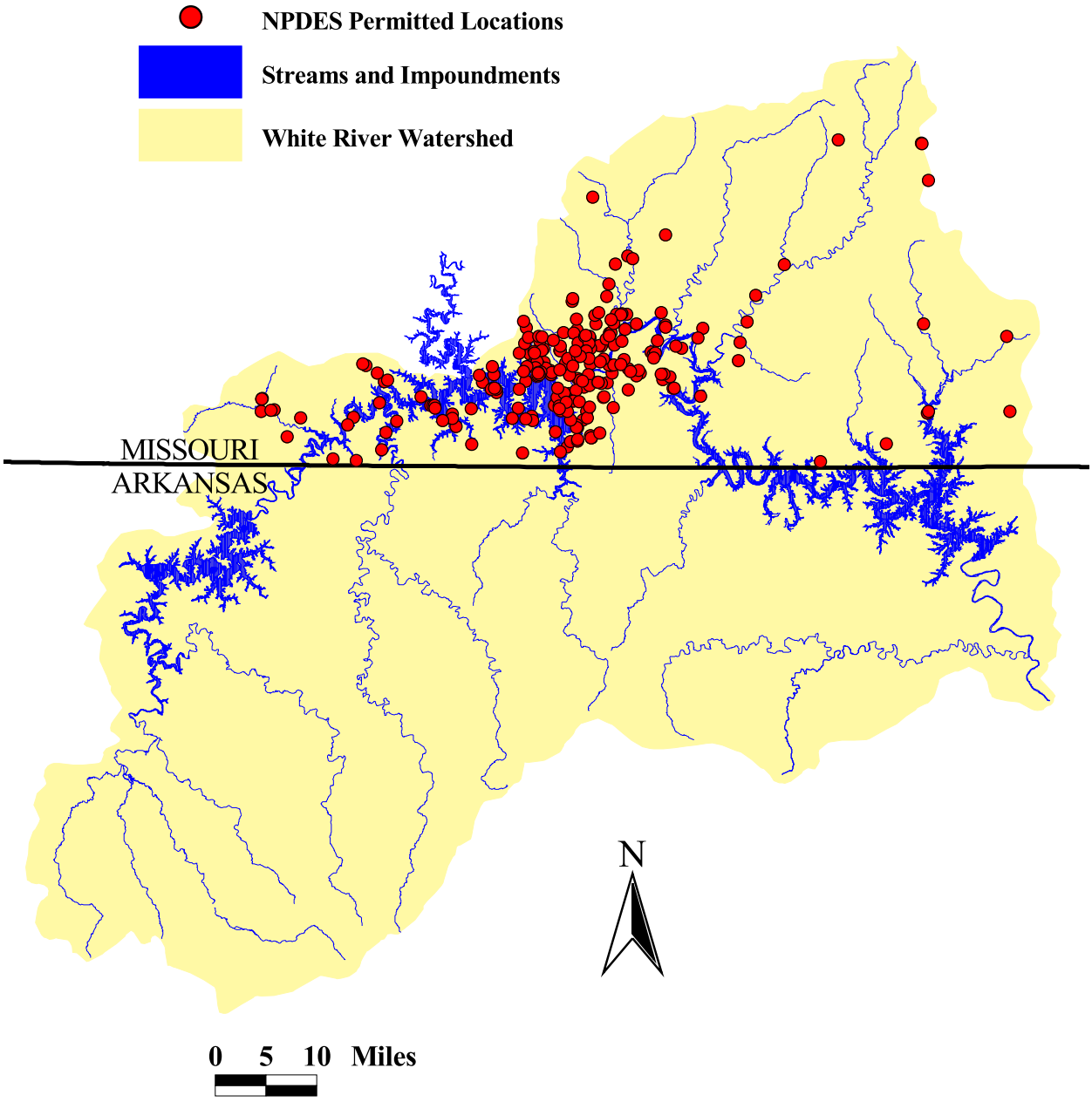


Note: WWTF numbers reference Table WQ04 and CAFO numbers reference Table WQ05.



Note: WWTF numbers reference Table WQ04 and CAFO numbers reference Table WQ05.

Figure WQ04. NPDES permitted locations in the Missouri portion of the White River watershed.



Source: MDNR (1998b).